AD-A045 438 FOREIGN TECHNOLOGY DIV WRIGHT-PATTERSON AFB OHIO F/G 9/2

JOURNAL OF SUN YAT SEN UNIVERSITY (SELECTED REPORTS).(U)

JUN 77

UNCLASSIFIED FTD-ID(RS)T-0684-77 NL

| OF |

AD
A045438

END
DATE
FILMED
11-77
DDC

FTD-ID(RS)T-0684-77

(1)

FOREIGN TECHNOLOGY DIVISION

JOURNAL OF SUN YAT SEN
UNIVERSITY (SELECTED REPORTS)

ACCESSION for		
NTIS	White Section	X
DDC	Buff Section	☐
UNANNOUNCED		☐
JUSTIFICATION		
BY		
DISTRIBUTION/AVAILABILITY CODES		
Dist.	AVAIL. and/or SPECIAL	
A		

FTD-ID(RS)T-0684-77

EDITED TRANSLATION

FTD-ID(RS)T-0684-77 7 June 1977

MICROFICHE NR: FTD-77-C-000673

JOURNAL OF SUN YAT SEN UNIVERSITY
(SELECTED REPORTS)

English pages: 32

Source: Acta Scientiarum Naturalium - Sunyatsen University, Number 4, 1976, pp. 19-29; 46-53

Country of origin: Hong Kong
Translated by: LINGUISTICS
F33657-76-D-0389
H. P. Lee

THIS TRANSLATION IS A RENDITION OF THE ORIGINAL FOREIGN TEXT WITHOUT ANY ANALYTICAL OR EDITORIAL COMMENT. STATEMENTS OR THEORIES ADVOCATED OR IMPLIED ARE THOSE OF THE SOURCE AND DO NOT NECESSARILY REFLECT THE POSITION OR OPINION OF THE FOREIGN TECHNOLOGY DIVISION.	PREPARED BY: TRANSLATION DIVISION FOREIGN TECHNOLOGY DIVISION WP-AFB, OHIO.

TABLES OF CONTENTS

Procedures of Testing the Existence of "Worst Arrangement" in Machine DJS--21

Computer-Mathematics Teaching and Research Center
Department of Mathematics and Mechanics
Sun Yat-sen University

I. Purpose

"Worst Arrangement" is at the present time a relatively accurate method to test magnetic core memory. It can be used to test the capability of resisting semi-selective interference of machine DJS-21.

II. Considerations of Worst Code Arrangement

In the magnetic core memory of thrice-forbidding current coincidence method, the cores can possibly fall into the following six different conditions:

(1) "I" - the condition of storing "I" information after "I" has been written on the core.

(2) "IR" - the condition of stable remanence after "I" information core receiving n-time of reading semi-selective interference.

(3) "IW" - the condition of stable remanence after "I" information core receiving n-time dipolar semi-selective interference.

(4) "O" - the condition of remanence after "O" has been

written on the core.

(5) "OR" - the condition of stable remanence after "O" information core receiving n-time reading semi-selective interference.

(6) "OW" - the condition of stable remanence after "O" information core receiving n-time dipolar semi-selective interference.

图 1

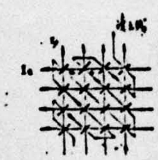


图 2

It is obvious that the magnetic cores are under different remanence conditions, and the dimension of their semi-selective interference signals caused by semi-selective reading current are not the same. In order to enable the signals of interference produced by the semi-selective cores on the reading cord to cancel each other, the reading cord must *in opposite directions pass through two cores* in the same line or same row in the core matrix (see a and b in Figure 2). Thus the reading signals on the reading cord are:

$$e = \pm(e_1 - 2e_2 \pm (n-2)e_3]$$

Among them: e_1 is the reading signal of the selected core.

e_2 is the semi-selective interference signals of two cores which can not cancel each other.

e_3 is the excess semi-selective interference signal of two cancelled cores (the difference of two semi-selective interference signals). Further discussion of e_3 will be our focal point hereafter.

It seems that if all the cores are of same quality, e_3 can be 0. But it is in fact not so. For instance, of the two cancelled cores, one is in the condition of "IW" and the other in "OR", and from Figure 1, it can be seen that the semi-selective interference signals produced by the two cores are not identical, (this is the main reason why e_3 is introduced). As a matter of fact, however, it is hardly possible to make all the cores completely same in quality.

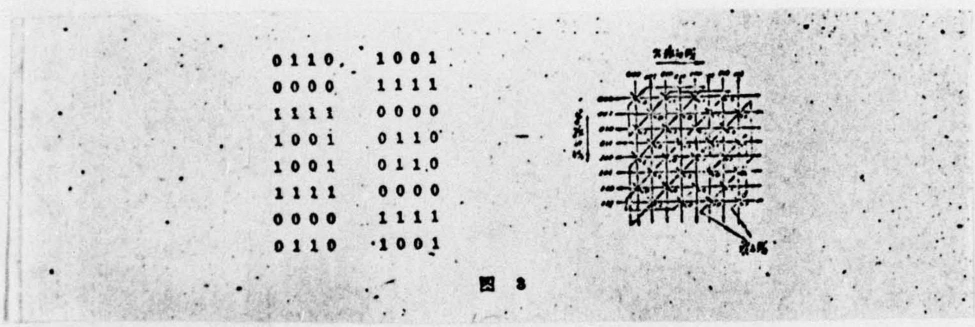
If some informations are distributed in a core matrix, and when the reading selected core is "I" signal, the polarity of all interference signals of e_3 will be contrary to that of "I" signal. When reading selected core is "O", the polarity of all interference signals of e_3 will be same as that of "O" signal. Such signals are the minimum "I" signal and maximum "O" signal, and they can be formulated respectively as follows:

$$e_{s1w\,min} = \pm[e_{s1w} - 2e_2 - (n-2)e_3]$$

$$e_{s0w\,max} = \pm[e_{s0w} - 2e_2 + (n-2)e_3]$$

This kind of code arrangement is called "Worst Arrangement". Obviously, when it is "worst arrangement", the ratio of "I" reading signal and "O" reading signal is lowered. It is one of the factors that are not good to internal stabilization.

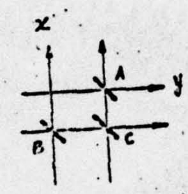
To combine with the structure of the magnetic core plate of machine DJS--21, in a pattern of 8 x 8 cores, it can mark out the cores, as illustrated in Figure 3, through which a reading cord passes and the worst code arrangement on a plate.



III. Implementation

In order to obtain minimum "I" reading signal and maximum "O" reading signal, in addition to arranging informations in accordance with the diagram of "Worst Arrangement", the cores must be put in a specially designed condition of remanence. In other words, the semi-selected cores which store "I" information are put in the condition of "IW" and those store "O" information are put in the condition of "OR". Only if "O" is written on one core outside the two drive cords which pass through the selected cores, all the cores on the drive cords

will be in the condition of "OR" or "IE". Then by writing "I" on the unit diagonal to the core of "I" information, the cores which are in the condition of "IR" will transfer to that of "IW". For the meaning of diagonal unit, see Figure 4. According to the diagram of "Worst Arrangement", the cores of "I" information on the two drive cords which pass through the checked units are equivalent and compensatory to each other. When the cores which return to condition of "IW" are identified as A and B, then outside those two drive cords, there is a unit c. Let the two drive cords which pass through c, again respectively pass through A and B, the unit c is a diagonal unit.



From analyzing Figure 3, it can be found out that the reading signal of the selected cords and the interference signal of e_3 are of same polarity. This means that the interference of e_3 amplifies "I" signal and depreciates "O" signal. So the information stored in the cores of the checked units should be reversed in advance.

In short, for achieving "Worst Arrangement", the following steps must be taken:

(1) Based on the address of the checked units and according to the diagram of "Worst Arrangement" to distribute codes in line and row, write down the address of the unit where "I" is distributed, then return the codes of the checked units.

(2) Write "0" on a diagonal unit nearing the checked unit.

(3) Write "I" in order on the diagonal units to line and row "I".

If the code arrangement as illustrated in Figure 3 is regarded as "Worst Arrangement", when the codes are taken back, it will, for the same reason, result in a "Worst Arrangement". Therefore, there are A and B two different diagrams of "Worst Arrangement".

	x →			
y ↓	0110	1001	1001	0110
	0000	1111	1111	0000
	1111	0000	0000	1111
	1001	0110	0110	1001
	1001	0110	0110	1001
	1111	0000	0000	1111
	0000	1111	1111	0000
	0110	1001	1001	0110
		A		B

In making arrangement, only the cores on the selected drive cords catch our attention. When the diagram of "Worst Arrangement" is examined in detail, it can be seen that the patterns of the codes on the drive cords of same direction are but one of the two forms or one of their reversed orders. In A, for example, the pattern of the codes on drive cord following direction x is one of 0110 1001 and 0000 1111 or 1001 0110 and 1111 0000. Thus the address codes of the drive cords which differentiate direction x and y can determine what pattern of arrangement should be in a checked unit. The codes arrangement in a core matrix of 64 x 64 is but a cycle of expansion of the codes in a core matrix of 8 x 8 toward direction x and y.

We take the address codes D_7, D_8, and D_9 as basis to determine

what pattern should be made on drive cord x, and D_1, D_2, and D_3 to determine what pattern should be made on drive cord y. The "line" in the following box diagram represents direction x and the "row" represents direction y.

IV. Application

(1) In order once to test one single unit, there are set up several switches: K_1, K_2, and K_3. They begin to work only after the paper tape has been inserted and started the 1000 band.

$K_1 = K_2 = K_3 = 0$ hour, test unit 1.

$K_1 = 1$ hour, test unit 2.

$K_2 = 1$ hour, test unit 3.

$K_3 = 1$ hour, test unit 4.

Hereafter, if $K_5 = 1$ hour, test again one of the present units (based on the instantaneous value of K_5). If $K_5 = 0$ hour, then test 1-2-3-4-1 units following their order in rotation. It takes about 6 minutes to test one unit.

(2) According to the content of the tested units, the total number of tests in this program is 32. Before each test, the core is brought back to the condition of remanence of the original arrangement. When an error is found in the test, it then stops at 10D1 right (or 10CF and cuu bright). At this time, the error can be found in the 1:1 ratio content of the register. The address of the error unit is at 1028 right.

(3) There are different ways to apply this program. Start 1000 if there is an intra-broadening device; otherwise begin with 1031. With the latter K_1, K_2, and K_3 will not work.

(4) Program punched address: 1000-10E9.

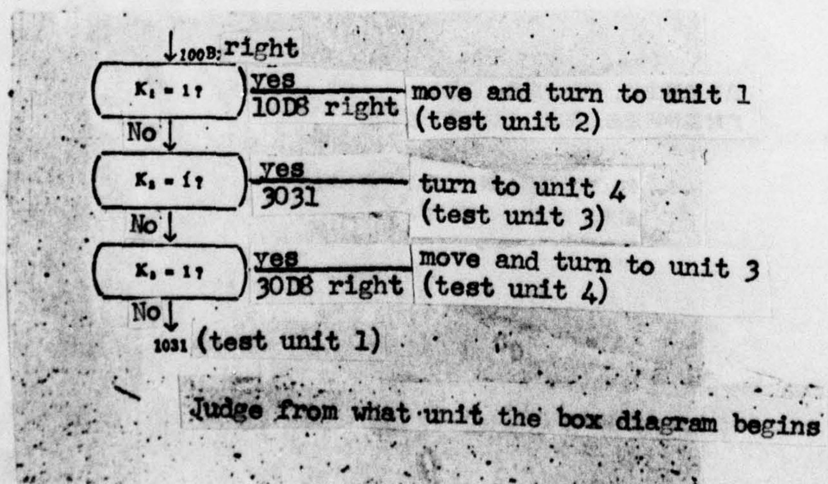
Instruction: 200 words in total

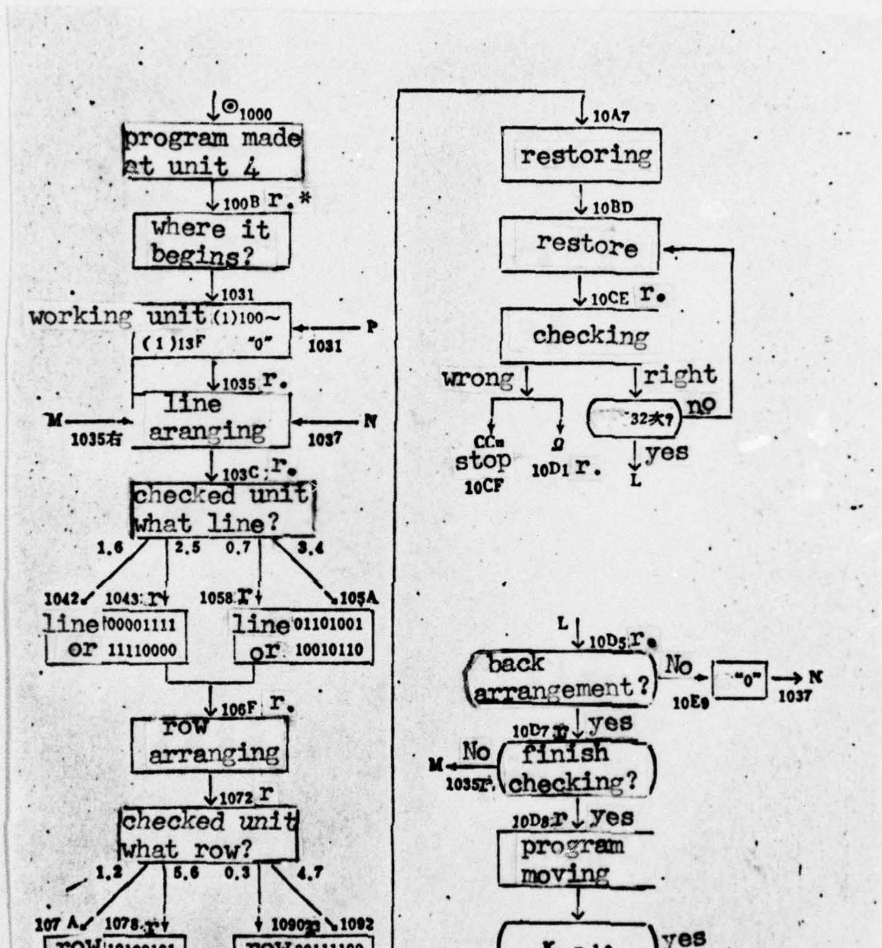
Constant: 28

Working unit: 71

In the box diagram, the operation should be adjusted according to different units. The address in the program refers to the situation when it operates with unit 2.

V. Box Diagram





* r. represents word "right"

VI. Program

```
1000  02 1023  }                 3    00 0000
      04 102A  }                      00 0003
   1  36 102A  }                 4    00 0000
      02 1010  } constant             00 0004
   2  37 102A  } move            5    00 0000
      04 3010  }                      00 0005
   3  35 102A  }                 6    00 0000
      20 1001  }                      00 0006
   4  02 101B  }                 7    00 0000
      04 102A  }                      00 0007
   5  36 102A  }                 8   -3F 3FFF   "1"
      02 1030  }                     -3F 3FFF
   6  12 102F  }                 9    00 0000
      37 102A  }                      00 1000
   7  04 3030  } program         A    00 1000   program move
      35 102A  } move                 00 1000   control word
   8  20 1005  }                 B    01 00BA
      02 30B7  }                      00 0000
   9  12 100F  }                 C    00 0000
      04 30B7  }                      00 003F
   A  02 30D4  }                 D    00 0000
      12 100F  }                      00 0FC0
   B  04 30D4  }                 E    01 0010
      26 0001    K1                   00 0000
   C  21 10D8                    F   -00 0010
      26 0002    K2                   00 0000
   D  20 3031                 1020    01 0000
      26 0004    K3                   01 0000
   E  21 30D8                    1    00 1000
      20 1031                         00 0000
   F  00 0000                    2    00 0020
      0J 2000                         00 0020
1010  00 0000    "0"             3    01 0020
      00 0000                         00 0000
   1  00 0000                    4    01 1000
      00 0001                         00 0000
   2  00 0000                    5    00 0000
      00 0002                         00 0041
```

```
6     01  0040
      00  0000
7     00  0000
      00  0000   following
                 is working
8     00  0000   unit
      00  0000
9     00  0000
      00  0000
A     00  0000
      00  0000
B     00  0000
      00  0000
C     00  0000
      00  0000
D     00  0000
      00  0000
E     00  0000
      00  0000
F     00  2000
      00  2000
1030  00  0000
      00  0000
1     02  1026
      04  1028
2     02  1010
      37  1028   working
3     04  1100   unit "O".
      35  1028
4     21  1032
      02  1024
5     04  1028
      02  1012
6     30  1029
      02  1018
7     04  102A
      04  102B
                 back to
8     02  1028   record "I"
                 information
                 addres con-
                 trol word.

      04  102C
9     02  1028   to form x direction
      10  101D   code control word
A     11  101E
      04  102D
B     28  1406
      10  1017
C     25  1058
      13  1017
D     25  1058
      13  1013
E     24  105A
      13  1014
F     24  105A
      13  1012
1040  25  1043
      13  1015
1     25  1043
      00  0000
2     02  102A
      12  1018
3     04  102A
      02  102A
4     13  1018
      24  104B
5     02  1010
      37  102D
6     04  0000
      37  102D
7     04  0000
      37  102D
8     04  0000
      37  102D
9     04  0000
      35  102D
A     20  104B
      21  106F
B     02  102D
      37  102C
```

```
   C   81  1100
       02  1018
   D   37  102D
       04  0000
   E   02  102D
       87  102C
   F   81  1100
       02  1018
1050   87  102D
       04  0000
   1   02  102D
       37  102C
   2   81  1100
       02  1018
   3   37  102D
       04  0000
   4   02  102D
       87  102C
   5   81  1100
       02  1018
   6   87  102D
       04  0000
   7   85  102D
       20  1045
   8   21  106F
       02  102A
   9   12  1018
       04  102A
   A   02  102A
       13  1018
   B   24  1066
       02  1010
   C   87  102D
       04  0000
   D   02  102D
       87  102C
   E   81  1100
       02  1018
   F   87  102D

       04  0000
1060   02  102D
       87  102C
   1   81  1100
       02  1018
   2   87  102D
       04  0000
   3   02  1010
       37  102D
   4   04  0000
       85  102D
   5   20  1066
       21  106F
   6   02  102D
       87  102C
   7   81  1100
       02  1018
   8   87  102D
       04  0000
   9   02  1010
       87  102D
   A   04  0000
       87  102D
       04  0000
       02  102D
   C   87  102C
       81  1100
   D   02  1018
       87  102D
   E   04  0000
       85  102D
   F   21  105B
       02  1023
1070   04  102C
       02  1028  }  to form y
   1   10  101C  }  direction
       11  101F  }  control word
   2   04  102D  }
       10  1017
```

```
3     25  1090
      13  1018
4     25  1090
      13  1014
5     24  1092
      18  1017
6     24  1092
      13  1011
7     24  107A
      13  1012
8     24  107A
      02  102B
9     12  1018
      04  102B
A     02  102B
      13  1018
B     24  1086
      02  1010
C     37  102D
      04  0000
D     02  102D
      37  102C
E     31  1120
      02  1018
F     37  102D
      04  0000
1080  02  1010
      37  102D
1     04  0000
      02  102D
2     37  102C
      31  1120
3     02  1018
      37  102D
4     04  0000
      35  102D
5     20  1086
      20  10A7
6     02  102D
      37  102C
7     31  1120
      02  1018
8     37  102D
      04  0000
9     02  1010
      37  102D
A     04  0000
      02  102D
B     37  102C
      31  1120
C     02  1018
      37  102D
D     04  0000
      02  1010
E     37  102D
      04  0000
F     35  102D
      21  107B
1090  20  10A7
      0?  102B
1     12  1018
      04  102B
2     02  102B
      13  1018
3     25  109D
      02  1010
4     37  102D
      04  0000
5     37  102D
      04  0000
6     02  102D
      37  102C
7     31  1120
      02  1018
8     37  102D
      04  0000
9     02  102D
      37  102C
A     31  1120
      02  1018
```

B	37	102D
	04	0000
C	35	102D
	21	109D
D	20	10A7
	02	102D
E	37	102C
	31	1120
F	02	1018
	37	102D
10A0	04	0000
	03	102D
1	37	102C
	31	1120
2	02	1018
	37	102D
3	04	0000
	02	1010
4	37	102D
	04	0000
5	37	102D
	04	0000
6	35	102D
	21	1093
7	00	0000
	02	1023
8	04	102A
	04	102B
9	04	102C
	02	1028
A	31	1027
	37	102A
B	02	1100
	13	1027
C	25	10AA
	10	101C
D	04	102D
	37	102B
E	02	1120
	13	1027

F	25	10AD	
	10	101D	
10B0	11	102D	
	12	1030	
1	37	102C	
	31	10BE	
2	02	10B1	
	12	1020	
3	04	10B1	
	35	102C	are there
4	21	10AA	32 times?
	36	1028	
5	02	0000	
	18	1018	
6	23	10B8	
	00	0000	
7	02	10CE	
	29	0000	
8	04	10CE	
	36	1028	checked unit
9	02	0000	reversed
	12	1018	
A	36	1028	
	04	0000	
B	02	1028	to form a neighbouring
	12	1025	diagonal unit address
C	12	1030	
	31	10BD	
D	02	1010	following is to restore arrangement
	04	0000	
E	02	1018	
	04	0000	
F	04	0000	
	04	0000	
10C0	04	0000	
	04	0000	
1	04	0000	
	04	0000	
2	04	0000	
	04	0000	

3	04	0000	
	04	0000	
4	04	0000	
	04	0000	
5	04	0000	
	04	0000	
6	04	0000	
	04	0000	
7	04	0000	
	04	0000	
8	04	0000	
	04	0000	
9	04	0000	
	04	0000	
A	04	0000	
	04	0000	
B	04	0000	
	04	0000	
C	04	0000	
	04	0000	
D	04	0000	
	04	0000	
E	04	0000	
	36	1028	
F	02	0000	
	13	1010	
10D0	24	10D2	
	13	1018	
1	24	10D2	an error operation stops
	3F	0000	
2	35	1022	
	20	10BD	
3	02	1022	
	30	1022	
4	02	10CE	
	29	0004	
5	04	10CE	arrange back?
	35	1029	
6	20	10E0	
	37	1028	

7	00	0000	have finished checking one unit?
	35	1028	
8	21	1035	
	02	1023	constant move
9	04	102A	
	36	102A	
A	02	1010	
	37	102A	
B	04	0010	
	35	102A	
C	21	10D9	
	02	101B	program move
D	04	102A	
	36	102A	
E	02	1030	
	12	101A	
F	37	102A	
	04	0030	
10E0	35	102A	
	21	10DD	
1	02	00B7	
	12	1019	
2	04	00B7	
	02	00D4	
3	12	1019	
	04	00D4	
4	02	003B	
	12	1021	
5	04	003B	
	26	0010	K_0
6	20	1031	
	02	1031	turn
7	10	101A	
	13	101A	
8	24	0031	
	20	2031	
9	02	1010	
	20	1037	

$GaAs_{1-x}P_x$ Luminous Materials of Open-Pipe Zinc Diffusion and Plane-Type

By

Lei Chien-chung Lo Chu-sheng
Sun Hsiao-hung Chia Hsüeh-chün
Students of Specialized Semiconductor Class, Department of Physics
Sun Yat-sen University

Solid and luminous articles of various colors and shapes made of wide forbidden band semiconductor and fluorescent materials are now being widely used to make indicating pieces in electronic industry. The material has such characteristics as long durability, high reliability, low cost, small size, and, above all, it is easy to be processed into various indicating articles. At the present time, the red electroluminescent material $GaAs_{1-x}P_x$ is one of the kind which is used most widely.

$GaAs_{1-x}P_x$ construction is a forward injection luminous material of p-n connection. This material is usually produced by using closed-pipe diffusion method with $ZnAs_2$ + P as diffusing media. In this way, however, the techniques required are complicated, reproducibility is low, poisonous and costly. Especially, the vapour pressure of the diffusion source is high, so it often results in high degree of concentration on the surface. As a consequence, its luminous efficiency is low and its defects become more. In order to improve the quality of the material and overcome the defects of the closed-pipe method, In recent years, the open-pipe diffusion method using zinc as direct diffusion source has developed.

For the purpose of lowering the drive current of luminous material $GaAs_{1-x}P_x$ and promoting its luminous efficiency, we in our factory undertake an experiment of open-pipe zinc diffusion, and have also tried to make production of limited quantity. The results show that in improving the characteristics of this luminous material, it is not only better than the closed-pipe method, and also the techniques required are simple, cost is low, and above all it is good for production.

I. Design

(1) $GaAs_{1-x}P_x$ material is of a structure of hybrid crystal of GaAs and GaP. The width of forbidden band and the pattern of radiative transition of GaAs and GaP are not the same, therefore, the width of forbidden band and the patern of ratiative transition of $GaAs_{1-x}P_x$ vary following the hybrid crystal ratio X. Figure 1 illustrates the relationship between the crystal constituents and the energy band structure of $GaAs_{1-x}P_x$.

The change of the width of forbidden band suggests the difference in energy of radiative quantium. Because of this, the luminous colors as can be seen are different. The other reason is, of course, that the light sensitivity of human eyes is different to various length of light waves. As far as the pattern of radiative transition is concerned, the quantium efficiency of direct transition is always much larger than that of indirect transition. So human reaction to the intensity of brightness of luminous articles is as a rule affected by the

efficiency of radiative quantum and human light sensitivity when various length of light waves comes into eyes. Experiment proves that the external quantum efficiency of $GaAs_{1-x}P_x$ material, following the eigenradiative wave of GaAs and GaP, will increase as the radiative length increased, but the light sensitivity of human eyes will reduce as that radiative wave length increased. So the reaction of human eyes to the brightness of luminous articles at a certain light wave length must have its best value. As indicated in Figure 2 and Figure 3, the best value is at 6600Å, which corresponds to forbidden band width of $GaAs_{1-x}P_x$, $E_g = 1.88$ev, the hybrid crystal ratio $X \simeq 0.4$. We, therefore chose to use $GaAs_{0.5}P_{0.4}$ material.

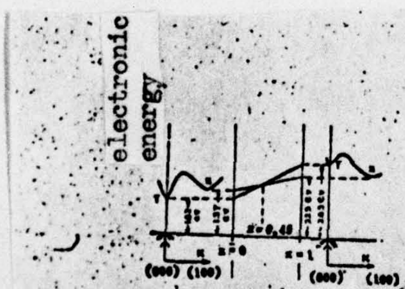


Figure 1 $GaAs_{1-x}P_x$ crystal constituents and energy band structure

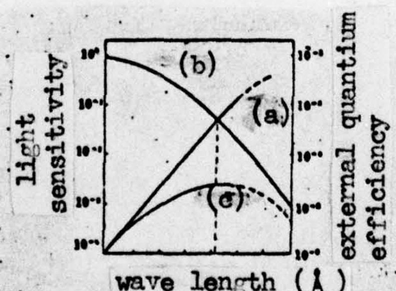


Figure 2 Relationship of (a) external quantium efficiency, (b) light sensitivity, and (c) antipodal light and wave length of $GaAs_{1-x}P_x$

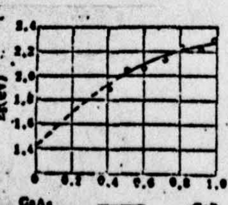


Figure 3 Relationship of forbidden band width Eg and hybrid crystal ratio X of $GaAs_{1-x}P_x$

(2) As P-type region of $GaAs_{0.6}P_{0.4}$ p-n connection is the main luminescence region, we select n-type $GaAs_{0.6}P_{0.4}$ as base material and the radiation acceptor impurity (Zn) forms a p-n connection. Such a structure enables the light quantum of p-n connection to radiate only through a thin P-type film. It thus reduces the absorption loss and increase luminous exitance efficiency.

To such injection luminous articles we must pay attention to the structure of p-n connection. Its injection efficiency is formulated as follows:

$$\gamma = \frac{1}{1+\frac{p_0\mu_p}{n_0\mu_n}} ; \qquad (1)$$

The electrons injected into P region recombines with the cavities there, and the high injection efficiency of luminous emission quantum can reduce the luminescence current and increase luminescence efficiency. It is therefore hoped that the concentration of base material donor N_D can be larger. But the injected electrons often pass through P-type region and recombine with the energy level of acceptor and demands the concentration of acceptor N_A and N_D to have considerable numerical value. In p-n connection formed by radiation method, the concentration of radiation acceptor impurity N_A must be at P-type region greater than the concentration of base material donor impurity N_D. For having a possible large injection efficiency, it is hoped that $N_A \simeq N_D$.

As for μ_n and μ_p, in GaAs material, it is usually $\mu_n > \mu_p$, but after

$N_D > 10^{17} Cm^{-3}$, μ_n is rapidly reduced following the increase of N_D. When $N_D > 10^{17} Cm^{-3}$, p-n connection breaking down the current pressure also rapidly becomes low. So the selection of n-type $GaAs_{0.6}P_{0.4}$, $N_D = 10^{17} cm^{-3}$ as base material is good to minimize the defect brought in by impurities, to promote luminescence efficiency and to lower luminescence current. It also enables p-n connection to break down the current pressure $V_B > 15V$.

(3) The light emitted from the region of p-n connection must pass through the thin film at P-type region in order to go out. But because of the ground state absorption of the semiconductor at P-type region, the luminous exitance is lowered. So the junction depth* there can not be too deep and it can not be too shallow either. If it is too shallow, the carriers injected in, before having completely recombined with the cavities, will enter into the ohmic electrode, and the effect of nonradiation recombination on the surface is strengthened. As a result, the luminescence efficiency becomes low.

Notice the recombination of the samll number of carriers and the light absorption phenomenon, for having the largest luminous intensity, there must be a very good chieh-shen (junction depth).

$$x_{jmax} = \frac{L_n}{aL_n - 1} \ln(aL_n) \qquad (2)$$

---

* The Chinese word chieh-shen, which literally means "knot deep", is tentatively translated as "junction depth". And hereafter a bilingual combination of chieh-shen (junction depth) is used in this work -- the translator.

Here X_{imax} - chieh-shen (depression knot) when total luminous intensity is the largest.

a - $GaAs_{1-x}P_x$ light absorption coefficient.

L - the diffusion length of electrons at P-type region.

Taking a model value of each aspect, $a \simeq 700Cm^{-1}$, $L_n = 1u$, then $X_{imax} \simeq 2.5u$. We therefore select $X_{imax} = 2.5u$.

(4) When a p-n connection is formed by diffusion method, the concentration of donor impurity makes a distribution of excess error function, and then a distribution of deceleration electric field of the injected electrons takes shape. Thus the electons tend to be limited to the electric charge recombination beside P-type region of p-n connection, and the effect of P-type film absorption on luminous exitance becomes greater. So in order to lessen the ladder-type distribution of P-type region donor's concentration, and to reduce the self-made electric fields, the surface concentration must be diminished. This leads to make the most part of P-type region as luminous emission zone and to minimize absorption loss. It is threefore hoped that the donor's surface concentration is $N_{Z_a} \simeq 10^{18} cm^{-3}$.

In addition, the quality of p-n connection formation will have great effect on the quality of luminescence. We believe that in the structure and the making of the connection, the introduction of non-radiation recombination must be limited to the least. For achieving this, attention should be paid to the effect of the quality of base materials and techniques applied.

There is a close relationship between luminous exitence of the luminescence diode and the way of manufacturing it and its appearance.

II. Experiment

There are two types of luminous articles, the terrace-faced and the plane. So far as the effective area of luminescence and the electric capability of the articles are concerned, the plane type is better than the terrace-faced one. In this experiment, we use zinc diffusion and plane techniques.

(1) Selection and manufacturing of film materials used to cover diffusion. Based on our experiment conditons. we use Si_3N_4 as film material to cover diffusion, and use high heating reaction of N_2H_4 + SiH_4 + H_2 group to prepare Si_3N_4.

(2) Selection and manufacturing of surface protection film materials. Under high temperature, the surface of GaAsP material has serious corrosion by zinc vapour. In order to lead zinc atomic diffusion entering into the crystal and to have perfect surface, the surface protection film must be used. At the same time, in the open-pipe diffusion, because of the absence of P As vaporization protection crystal under high temperature, P As atom will volatilize from GaAsP crystal and change their proportion. This is why we use surfacr protection film.

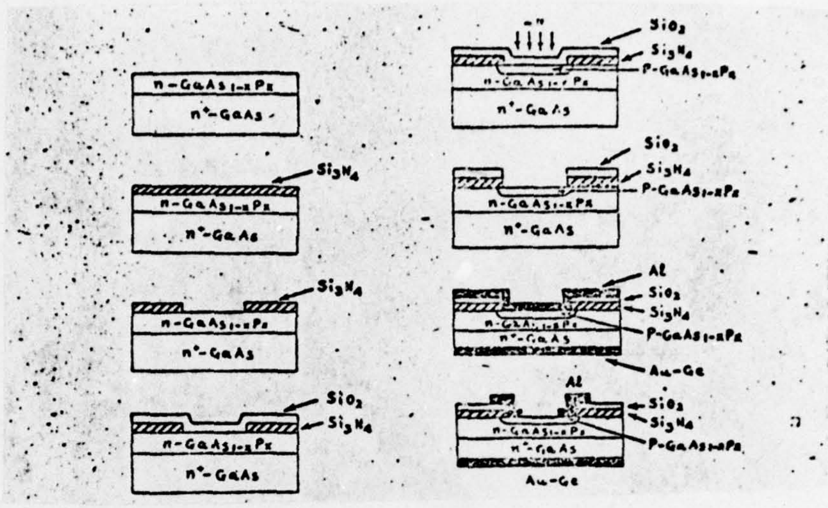
To use SiO_2 as surface protection film has two-fold advantages, On the one hand, it does not block zinc atom from entering into the crystal

to diffuse, and on the other hand, it can prevent corrosion of the surface and the change of ratio between phosphorus and arsenic. We use ethyl silicate low temperature sedimentation method to prepare SiO_2 protection film.

(3) Selection of formation gas. Element zinc is vary active, and under high temperature, it is easy to be oxidized. GaAsP under high temperature is also easy to be oxidized. So the selection of formation gas for open-pipe diffusion and the techniques deserve careful and detailed consideration.

For the purpose of protecting zinc source and GaAsP crystal plate from oxidation under high temperature, we use highly pure N_2 and H_2 as formation gas. To add H_2, because of its reducibility, will achieve a better protection from oxidation After putting it into model pieces, let the excess oxygen be thoroughly expelled, and then place the model piece under high temperature to diffuse.

(4) Procedures of Applying Techniques. Figure 4 illustrates the procedures:



(a) base material (b) growing of Si_3N_4 (c) first time let light in
(d) growing of SiO_2 (e) zinc diffusion (f) second time let light in
(g) vaporization electrode (h) no light in

Figure 4 Main technical procedures of making the open-pipe experiment.

(5) Conditions of Si_3N_4 Growth, SiO_2 Growth and Zn Diffusion Experiment

(1) Si_3N_4 Film Growth

We use $SiH_4 + N_2H_4 + H_2$ group high heating reaction method. Figure 5 illustrates the principles of setting up Si_3N_4 growth experiment.

The chemical equation is as follows:

$$3SiH_4 + 3N_2H_4 \xrightarrow[\Delta]{H_2} Si_3N_4\downarrow + 2NH_3\uparrow + 9H_2\uparrow$$

The reaction temperature is about 750°C - 800°C. If the temperature is too high, it will result in film crack. Through controling of the quantity of

flow, the speed of growth of SiH_4, N_2H_4 and H_2 is managed at a rate of about 250Å/min. Experiment proves that there are about 2500Å Si_3N_4 film in the form of sediment on $GaAs_{1-x}P_x$ crystal plate, and their effect of covering Zn diffusion is very good.

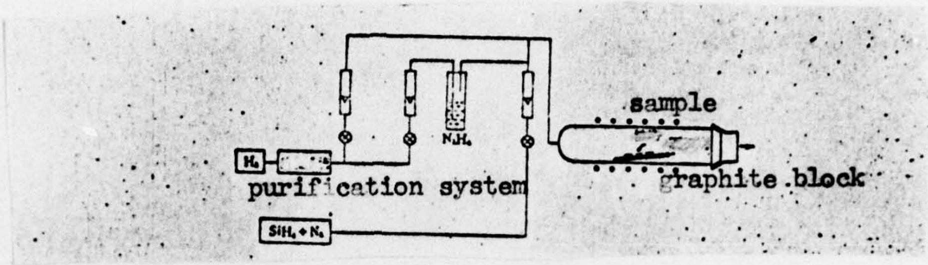


Figure 5 Diagram of Installation for Experiment of Si_3N_4 growth

(2) SiO_2 Protection Film Growth

We use ethyl silicate vacuum hot decomposition method to deposit SiO_2 film as indicated in Figure 6. The chemical equation is as follows:

$$Si(OC_2H_5)_4 \xrightarrow[\Delta]{} SiO_2\downarrow + H_2\uparrow + CO\uparrow + CH_4\uparrow + \cdots\cdots$$

To adjust the degree of vacuum appropriately at temperature 680°C and source temperature 23°C, the speed of deposition is about 40Å/min. Select those protection films, of which the thickness is 2000Å ~ 3000Å.

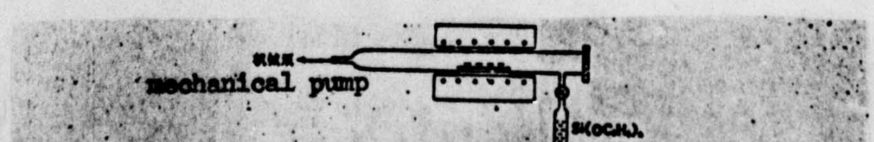


Figure 6 Installation of hot decomposition to deposite SiO_2

(3) Diffusion

We adopt open-pipe diffusion method of double temperature zone and control the source temperature Tz and flake temperature Tw respectively. Place zinc at the source temperature zone, and GaAsP crystal flake at the flake temperature zone, and use highly pure $N_2 + H_2$ to bring the source vapour to the flake temperature zone to start and carry on diffusion. The diagram of instalation is shown in Figure 7.

The diffusion source is 99.999% pure zinc, and its color becomes silver grey after being rinsed in $HCl:H_2O$. The source quantity is determined by source temperature, quantity of vapour and the length of time used for diffusion. (under our typical condition of experiment, the source quantity is about 2 ~ 3 g.)

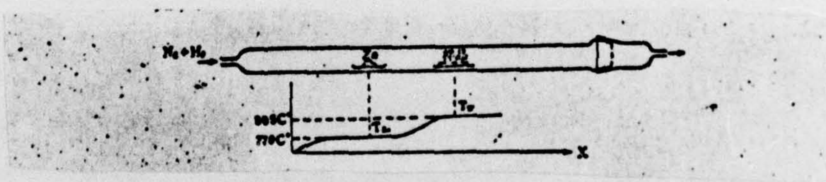


Figure 7 Diagram of the principle of installation for open-pipe diffusion

After placing the source and flakes into quartz tube, the important measure taken is to expel the excess oxygen. This will guarantee that the source will not be oxidized and that the diffusion will be normal. We first place the source and the flakes according to the opposite position of temperature zone,

and they are all at the low temperature outside the temperature zone. First let the highly pure N_2 flow in for 15 minutes, then $N_2 + H_2$ mixture for 15 minutes, finally move the quartz tube and let both source and flakes enter into diffusion temperature zone to diffuse. 15 minutes before the ending of diffusion, close H_2 and use N_2 to push the remnant H_2 out.

Typical diffusion conditions:

Temperature: flake temperature $T_W = 805^oC$; source temperature $T_{Z_n} = 770^oC$.

Time: 75' (including after moving the quartz tube in 10' to raise temperature to the degree of normal diffusion, and the time used for expelling the remnant H_2)

Gas flow quantity: $N_2 \simeq 230$ml/min, $H_2 \simeq 150$ml/min. When it is used to expel remnant H_2, $N_2 \simeq 550$ml/min.

Diffusion result: $X_j \simeq 2.5\mu$ $R_\square \simeq 50 \sim 60\Omega/\square$. If the diffusion result is required to change, it must begin with changing temperature and the length of time of diffusion and to conduct further experiment.

III. Result and Discussion

(1) The effect of SiO_2 protection film on diffusion parameter. SiO_2 protection film of different thickness diffuse under conditions that $T_W = 805^oC$, $T_{Z_n} = 770^oC$, and diffusion time = 120', the result will be that as indicated in Table 1.

Table I Relationshp of SiO_2 Thickness, chieh-shen (junction depth) and Film Electric Resistance

time of SiO_2 deposition	film color	thickness (Å)	chieh-sheh (μ)	R_s ($\Omega/\square$)	surface condition
20'	dark blue	1250	3	72	good
30'	light blue	1500	3	54	good
40'	l. yellow	2000	3	65	good
50'	yellow to red	2500	3	60	good
0'	no	0	5	14	corroded

From above Table, it can be seen that SiO_2 thickness has no effect on chieh-shen (junction depth). But the tendency of R numerical value suggests that SiO_2 thickness has effect on reducing surface concentration of diffusion. Obviously, R of open-pipe method is greater than that of closed-pipe method. This means that the surface concentration of open-pipe diffusion is lower than that of closed-pipe diffusion.

Again from Table II, we can see that the increase of SiO_2 thickness can improve luminescence quality. This is probably related to the fact that because of the increase of SiO_2 thickness, the concentration of diffusion surface donor is decreased and this leads to lessen the defect at P-type region and the ladder-type reduction of the concentration of acceptor impurity. However, SiO_2 film can not be too thick, if SiO_2 film can not match the quality of thermal expansion of the base material, crack s will occur, and consequently it will have no function of surface protection. When the thickness of SiO_2 is smaller than 700Å, it can not protect the surface either. So we select SiO_2 film with thickness of 2000Å - 3000Å as protection film.

Table II Relationship Between Thickness of SiO_2 Film amd Brightness

SiO_2 thickness (Å)	chieh-shen (μ)	antipodal brightness
1000	3.7	16
1250	3.7	19
2000	3.7	24
3000	3.7	33

(2) Relationship between luminescence characteristics and chieh-shen (jnuction depth). Figure 8 illustrates the relationship between luminescence characteristics of luminescence diode and chieh-shen (junction depth). From the curve line in the Figure, it can be seen that at a certain numerical value of chieh-shen (junction depth), there lies the greatest brightness. If chieh-shen (junction depth) is too shallow, the luminous efficiency will become low because deffects at P-type region increase and the elements of non-radiation recombination become more, and also a part of unbalance carriers enter into electrode before they have chance to be recombined. However, if chieh-shen (junction depth) is too deep, the quantium of p-n connection can radiate only after passing through P-type film, and the increase of light absorption at P-type region lowers the efficiency of the external quantium. From what the curve indicates in the Figure, chieh-shen (junction depth) X should be 2.5 ≃ 3.5μ.

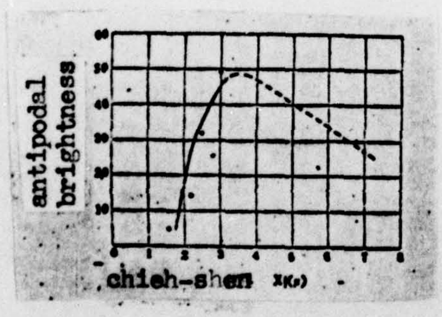


Figure 8 Relationship between Brightness and chieh-shen (junction depth)

With same chieh-shen (junction depth), but the diffusion source

temperature Tz and the flake temperature Tw changed and the impurity distribution of the connection also changed, this will affect luminescence quality as well. So temperature is also an important factor.

(3) Peak wave length and half width of wave length. Figure 9 shows the curve of spectrum characteristics under the typical condition of experiment.

From a survey, it becomes known that the peak wave length of the radiation spectrum of $GaAs_{0.61}P_{0.39}$ luminous diode is 6520Å. From the relation curve of the constituents ratio X of $GaAs_{1-x}P_x$ material and the width of forbidden band, it is found out that when X = 0.39, the width of forbidden band is 1.9eV and the peak wave length of radiation is about 6520Å. This proves that the ratio of phosphorus and arsenic remain unchanged.

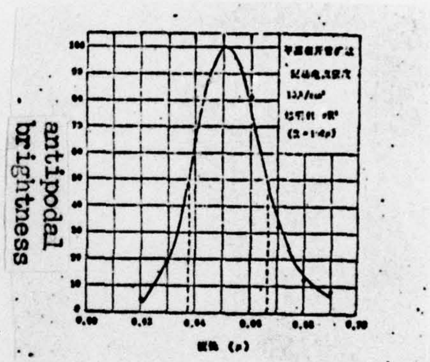


Figure 9 Distribution curve of spectrum of luminescence diode in a plane-type open-pipe diffusion

The half width of luminescence spectrum is about 280Å, and it is basically symmetrical to extend toward the long wave and the short wave. Extension toward the direction of short wave is the result of indirect transition, and toward the direction of long wave reflects a fact that various luminescence energy levels exist in the forbidden band. If the homogeneity of materials can be improved and a strict rule to prevent the introduction of external impurities can be worked out in techniques,

the half width of spectrum can be further reduced.

(4) The covering effect of diffusion. Experiment suggests that if the temperature of Si_3N_4 growth is too high and the speed of growth is too high, cracks of Si_3N_4 will occur (caused by inability to match the quality of thermal expansion). Then there will be no action of covering diffusion. However, when the thickness of Si_3N_4 is less than 1500Å, even the quality of growth is good, there will be no way to avoid that zinc atoms by breaking down the covering film enter into the crystal and form a shallow p-n connection on the flake as indicated in Figure 10. This shallow junction can be exposed by exposing liquid, but it can not become luminescent even it is given a forward bias. So far as the luminescence efficiency is concerned, it seems to have some covering function because the driive current increased. When the thickness of Si_3N_4 increased to 2000Å - 3000Å, this shallow junction disapears, and the action of covering begins. We usually use Si_3N_4 film of 2500Å, and the covering effect is very good.

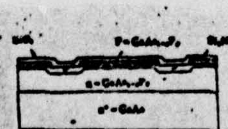


Figure 10 As Si_3N_4 film is too thin and can not have the covering function, at the lower part of covering film P^--$GaAs_{1-x}P_x$ film is formed.

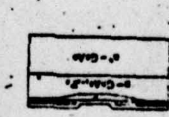


Figure 11 Transverse diffusion

In experiment, we found transverse diffusion phenomenon as illustrated in Figure 11. The transverse diffusion was produced by the stress between Si_3N_4 filme and $GaAs_{1-x}P_x$ crystal. Due to the existence of this stress, on the boundary face there is a position error. Zinc atoms following these defects rapidly diffuse and enlarge the size of the junction, increase the drive current and lower the luminescence efficiency.

The existence of transverse diffusion is the inherent defect of using Si_3N_4 as covering material. It affects in a certain degree the electroluminescence quality of articles. Recently Al_2O_3 and phosphor-silicate were used glass as covering material. The quality of thermal expansion of these materials is very close to that of GaAsP material, they can diminish transverse diffusion and improve the quality of articles.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: FTD-ID(RS)T-0684-77
2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle): JOURNAL OF SUN YAT SEN UNIVERSITY (SELECTED REPORTS)
5. TYPE OF REPORT & PERIOD COVERED: TRANSLATION
6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s)
8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Foreign Technology Division, Air Force Systems Command, United States Air Force
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS
12. REPORT DATE: 1976
13. NUMBER OF PAGES: 32
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)
15. SECURITY CLASS. (of this report): UNCLASSIFIED
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report): Approved for public release; distribution unlimited.
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)
18. SUPPLEMENTARY NOTES
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
20. ABSTRACT (Continue on reverse side if necessary and identify by block number): 09; 12

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

DISTRIBUTION LIST

DISTRIBUTION DIRECT TO RECIPIENT

ORGANIZATION		MICROFICHE
A205	DMATC	1
A210	DMAAC	2
B344	DIA/RDS-3C	8
C043	USAMIIA	1
C509	BALLISTIC RES LABS	1
C510	AIR MOBILITY R&D LAB/FIO	1
C513	PICATINNY ARSENAL	1
C535	AVIATION SYS COMD	1
C557	USAIIC	1
C591	FSTC	5
C619	MIA REDSTONE	1
D008	NISC	1
H300	USAICE (USAREUR)	1
P005	ERDA	1
P055	CIA/CRS/ADD/SD	1
NAVORDSTA (50L)		1
NAVWPNSCEN (Code 121)		1
NASA/KSI		1
AFIT/LD		1

ORGANIZATION		MICROFICHE
E053	AF/INAKA	1
E017	AF/ RDXTR-W	1
E404	AEDC	1
E408	AFWL	1
E410	ADTC	1
E413	ESD	2
	FTD	
	CCN	1
	ETID	3
	NIA/PHS	1
	NICD	5